SL263

UF UNIVERSITY of FLORIDA
IFAS Extension

Salmonella and tomatoes: Q & A for consumers[1]

Max Teplitski, Keith Schneider and Michelle Danyluk[2]

Many pressing questions about microbiological safety of fresh fruits and vegetables have arisen since the recent outbreak of salmonellosis linked to the consumption of tomatoes. These concerns are related, as well, to previous outbreaks of gastrointestinal illnesses caused by *E. coli* O157:H7, which were linked to leafy greens. The following draws upon recent published peer-reviewed research to address some of the most common of those questions.

Q. Is eating fresh produce risky?

Each of us on a daily basis comes into contact with various pathogens. To date, the most recent outbreak of produce-associated salmonellosis has been linked to about 300 cases in 23 states. Approximately 30 percent of people in these states report consuming fresh tomatoes on a daily basis. Therefore, one out of the 3.7 million people who consume tomatoes daily has developed salmonellosis-like signs. These calculations demonstrate that most of us ingest or inhale hundreds of pathogens daily without ever becoming sick. Typically, at least several thousand cells of *Salmonella* are required to cause salmonellosis in healthy adults (although one outbreak of salmonellosis resulted from consuming as few as four *Salmonella* cells per serving of ice cream (6)).

Q. I had diarrhea this morning. Is that salmonellosis?

Only your doctor can diagnose salmonellosis. The gastroenteritis symptoms associated with salmonellosis are much more severe than those of an upset stomach. Symptoms of salmonellosis include headaches, abdominal pain, nausea and fever. Gastroenteritis usually resolves itself within a few days without antibiotic treatment in otherwise healthy adults. Those who are at higher risk (pregnant women, children, elderly people, and anyone who has undergone recent antibiotic therapy or immunosuppression treatment) should consult their physicians at the first signs of the disease.

Q. How do Salmonella, E. coli O157:H7 and other human pathogens contaminate tomatoes and other fruits and vegetables?

There is no quick answer to this question. Scientists are still debating the most likely routes of produce contamination. It is possible for produce to be contaminated at various stages, including during cultivation, harvest, cleaning, washing and distribution. In the field, fruits and vegetables can be contaminated by coming in contact with animal

1. This document is SL263, one of a series of the Soil and Water Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date June 2008. Visit the EDIS Web Site at http://edis.ifas.ufl.edu.
2. Max Teplitski, assistant professor, Soil and Water Science Department; Keith Schneider, associate professor, Food Sciences and Human Nutrition Department, University of Florida Institute of Food and Agricultural Sciences, Gainesville, FL; and Michelle Danyluk, assistant professor, Microbiology Department, UF-IFAS Citrus Research and Education Center--Lake Alfred, FL.

manure or poultry litter that was improperly composted. Bird, animal and insect droppings can occasionally land on produce in the field and deposit pathogens on surfaces. Additionally, improper personal hygiene of workers who handle produce in the field and/or during packing can also breach the microbiological safety of fruits and vegetables. Cross-contamination in retail and during food preparation at home and in restaurants has also been documented (3).

Additionally, it is not clear whether *Salmonella* and *E. coli* O157:H7 contaminate only surfaces of fruits and vegetables or whether these bacteria are able to efficiently colonize internal parts of the plant. Laboratory studies using high doses of bacteria suggest that Salmonella and E. coli O157:H7 contaminate produce in the field by colonizing plant-root surfaces from infested soil or seeds. Bacteria then spread to all parts of the plant (9). In controlled field studies when *E. coli* and *Salmonella* were artificially mixed with animal manure, bacteria were able to contaminate all parts of the plants (1, 7, 8, 10).

It is also possible that *Salmonella* and *E. coli* O157:H7 can directly colonize leaves and stems by entering through wounds or through stomata (openings on leaves through which plants “breathe”). While these studies provide hints about potential routes of plant infection, there is still no clear indication which, if any, of these contamination routes have led to an outbreak of salmonellosis in humans (reviewed in reference 4).

Q. Can consumers visually inspect produce to identify fruits and vegetables that are contaminated with Salmonella or E. coli O157:H7?

No. Even in studies in which fruits and vegetables were artificially contaminated with high doses of *Salmonella* or *E. coli* O157:H7, the produce did not show signs of spoilage, did not have an unpleasant odor, and did not differ in appearance from uncontaminated fruits and vegetables. The likelihood that produce contaminated with these pathogens will not show any visible signs may be due to the fact that neither *Salmonella* nor *E. coli* O157:H7 has evolved as plant pathogens. They cannot efficiently degrade plant tissues or cause visible spoilage of produce.

While *Salmonella* and *E. coli* O157:H7 cannot cause produce decay, one survey has demonstrated that fresh or cut fruits and vegetables sampled from various supermarkets are twice more likely to harbor *Salmonella* if they are already affected by “bacterial soft rot” (14). Soft rot is a produce decay caused by plant-pathogenic bacteria. The best advice, therefore, is to purchase intact, uninjured fruit and vegetables.

Consumers may also want to consult the Food and Drug Administration s Website http://www.fda.gov/oc/opacom/hottopics/tomatoes.html; it provides the most recent information on the types of tomatoes being recalled.

Q. Is there anything consumers can do to reduce the risk of infection?

1) When selecting fruits and vegetables at the market, do not pick damaged produce. Additionally, avoid selecting fruits and vegetables that are too soft or have translucent skin. Even though *Salmonella* and *E. coli* O157:H7 do not cause produce decay, damaged fruits and vegetables are more likely to also contain these human pathogens. Additionally, consumers should avoid fruits and greens that are soiled.

2) Store your produce dry and in a cool place. While storing produce at cooler temperatures does not consistently reduce potential contamination, it may help prevent any pathogens that may already be present from multiplying to levels more likely to be dangerous to humans (15).

3) Never soak vegetables in water. Soaking fresh vegetables in water may increase the chance that any bacteria present on the surface of the vegetable will infiltrate into the inner tissues.

4) Fruits and vegetables that have been minimally processed (i.e. thoroughly washed and brushed, cut, sliced, peeled, lightly cooked, etc) should be stored refrigerated and only for a limited time.

5) Clean your refrigerator. Regularly wipe refrigerator shelves and crispers with a household cleaner.

6) Washing produce is an important way to remove some contamination on the surface of fruits and vegetables. Thoroughly washing produce in warm water with common detergents reduces, but does completely eliminate bacteria on surfaces of tomatoes (12). When washing fruits and vegetables at home, consumers should make sure that detergents are food-grade and approved by the FDA for this purpose and do not contain any harmful chemicals. Fruits and vegetables should be washed under clean, running warm water. Do not wash your vegetables or fruits in bleach solutions as they are not considered safe for consumption.

Wash fruits and vegetables immediately prior to eating them. Washing removes fruits natural protective wax coating, and brushing will abrade the skin. Thorough cleaning prior to extended storage will reduce the shelf life of produce and create potential routes for contamination. Additionally, washing is not likely to remove *Salmonella* or other human bacterial pathogens that may have gotten inside the produce. In terms of produce with rough surfaces -- such as cantaloupes, strawberries, broccoli, cauliflower -- washing is only modestly effective in removing pathogens.

7) When slicing tomatoes, cut out the stem scar, the corky area on top of a tomato fruit that was attached to the stem. Studies using artificial contamination show that after tomatoes are picked and soaked in a suspension containing *Salmonella*, the stem scar contains higher numbers of bacteria (15).

8) When preparing fruits and vegetables at home, avoid cross-contamination of fruits and vegetables from meats, poultry, and seafood, as well as from vegetables (such as potatoes and leeks) and cucurbits (melons, squash) that are normally soiled.

Q. I only buy organic produce. This pretty much means that it is safe, right?

Not necessarily. While organically grown produce may not have pesticide residues, it is not necessarily more likely than conventionally grown produce to be free of *Salmonella* or other microbial contaminants. Because the organic market is still quite limited, direct comparison of microbiological safety of organic and conventional produce is difficult to achieve. It is possible that because organic farmers rely heavily on manure and poultry litter to fertilize fields, organic methods of production may be more likely to inadvertently contaminate vegetables in cases when manure and poultry litter are not properly composted. A small-scale survey of organic and conventionally produced vegetables in Minnesota supported this hypothesis (11).

We note again that because the organic market is very limited, scientific debate on the safety of organic produce remains ongoing. This debate is exemplified by an exchange in *Nature*, one of the flagship scientific publications: http://www.nature.com/nbt/journal/v25/n2/full/nbt0207-165b.html.

Q. I always have a drink of alcohol with my food. This keeps me safe from bacteria, right?

There is no direct answer to this question. Generally, consumption of alcohol is considered to suppress immune system, and consuming alcohol in excess impairs judgment and most certainly leads to many risky behaviors. Research shows that the immune systems of “sober” mice and mice that were fed ethanol responded differently when the mice were exposed to *Salmonella* (12). (It should be noted, as well, that unlike humans and other primates, mice respond to a *Salmonella* infection with typhoid-fever-like symptoms when they are exposed to non-typhoidal *Salmonella* (13).) Additionally, a very limited survey of 51 persons exposed to tomatoes contaminated with *Salmonella* during an outbreak in Spain suggested that having a drink may have modestly reduced the risk of getting infected (2).

Q. What are scientists doing to ensure safety of produce?

Scientists around the world and at University of Florida/IFAS are working to improve the safety of fresh fruits and vegetables. Ongoing scientific studies focus on ways to eliminate reservoirs of pathogens in the field, in greenhouses, and in facilities for washing and packing. Also under examination are questions of how these bacteria attach to fruits and vegetables and the fate of *Salmonella* and *E. coli* O157:H7 on or in fresh produce following harvest, including studies of how these bacteria multiply or die once they reach produce and what behaviors in processing or delivery to consumers affect these pathogens. Answers to such questions will help scientists disrupt these pathogens, possibly with new formulations of washes or sprays. A prototype wash solution for tomatoes was developed that contains water, oleic acid, glycerol, ethanol, potassium hydroxide, sodium bicarbonate, citric acid, and distilled grapefruit oil. This wash solution reduced surface contamination of tomatoes with Salmonella by 100-10,000 fold (4).

Additionally, a formulation for an edible film that contains glycerin, soy protein and malic acid with the potential to prevent growth of Salmonella and other pathogens has been registered with the US Office of Patents and Trademarks (6). Consumers should be warned, however, not to attempt to concoct similar formulations at home; before washes or edible films are approved by FDA, they undergo rigorous testing to ensure that each component of the wash is safe.

Also under study is the need for improved conditions and hygiene of workers involved in growing, harvesting and processing fruits and vegetables. Scientists are studying DNA-fingerprinting techniques to quickly identify a pathogen and link it to a potential source of infection.

The Florida tomato industry has recently instituted a Tomato Good Agricultural Practices (T-GAPs) program. As a part of this program, educators at the University of Florida/IFAS are providing food-safety training to all Florida growers and processors. Strict adherence to GAP principles ensures the safest product possible. The Florida Department of Agriculture and Consumer Services is enforcing a new rule that requires all tomatoes produced in Florida to be treated with a sanitizer before being marketed.

Q. Why is it taking so long to identify where contaminated tomatoes come from? How do scientists track the source of pathogens, anyway?

Linking an outbreak to a specific source generally requires some time. First, epidemiologists need to identify what patients have in common. Examples of the kinds of questions epidemiologists need to answer include the following: Did the people who got sick eat the same type of food? Did they go to the same restaurant?

Once the source of “pathogen X” is narrowed down (i.e. “food A” or a “restaurant chain Y”), scientists will then attempt to identify whether a specific batch of the product was contaminated. Fresh produce, such as tomatoes, often travels long distances before being sold and consumed. Tomatoes are not individually labeled when being shipped. They often are mixed with other tomatoes of similar variety and ripeness, but originating from other growing areas. This mixing process makes it very difficult for epidemiologists to pinpoint the source or farm that produced the contaminated tomatoes.

Once the “pathogen X” is identified in a sample of “food A,” geneticists will use specific DNA fingerprints of the pathogen to compare it to the known DNA fingerprints of other isolates of the same pathogen to see whether there is a close match. Once these genetic fingerprints of different isolates of the pathogen are matched, they become one piece of evidence linking an outbreak to a specific field or perhaps a packing facility.

Additional information on tomato safety can be found at the following Web sites:

http://www.foodsafety.gov/~dms/tomatqa.html

http://www.doacs.state.fl.us/press/2008/06102008.html

http://www.cfsan.fda.gov/~dms/tomatqa.html

Additionally, the EDIS publications listed below detail steps each consumer can take at home to reduce the risk of various gastrointestinal illnesses.

Petridis, H., G. Kidder, and A. Ogram. 2002. *E. coli* O157:H7 A Potential Health Concern. UF/IFAS EDIS Fact Sheet SL146. http://edis.ifas.ufl.edu/ss197.

Schneider, K. R., R. M. Goodrich, and M. A. Kirby. 2003. Preventing Foodborne Illness: *E. coli* O157:H7. UF/IFAS EDIS Fact Sheet FSHN031. http://edis.ifas.ufl.edu/fs097 .

Schneider, K. R., R. M. Goodrich, and S. Z. Waithe. 2003. Preventing Foodborne Illness: Salmonellosis. UF/IFAS EDIS Fact Sheet FSHN0214. http://edis.ifas.ufl.edu/fs096 .

Simonne A., J. Brecht, S. Sargent, M. Ritenour, and K. R. Schneider. 2005. Good Worker Health and Hygiene Practices: Training Manual for Produce Handlers. UF/IFAS EDIS Fact Sheet FCS8769. http://edis.ifas.ufl.edu/fy743

References

1. **Barak, J. D., and A. S. Liang.** 2008. Role of soil, crop debris, and a plant pathogen in *Salmonella enterica* contamination of tomato plants. PLoS ONE 3:e1657.

2. **Bellido-Blasco, J. B., A. Arnedo-Pena, E. Cordero-Cutillas, M. Canos-Cabedo, C. Herrero-Carot, and L. Safont-Adsuara.** 2002. The protective effect of alcoholic beverages on the occurrence of a *Salmonella* food-borne outbreak. Epidemiology 13:228-30.

3. **Bidol, S. A., E. R. Daly, R. E. Ricker, T. A. Hill, T. H. Taylor, M. F. Lynch, J. A. Painter, C. R. Braden, P. A. Yu, L. Demma, C. Barton Behravesh, C. K. Olson, S. K. Green, A. M. Schmitz, D. D. Blaney, and M. D. Gershman.** 2007. Multistate outbreaks of *Salmonella* infections associated with raw tomatoes eaten in restaurants --- United States, 2005--2006. CDC Morbidity and Mortality Weekly Report 56:909-911.

4. **Heaton, J. C., and K. Jones.** 2007. Microbial contamination of fruit and vegetables and the behaviour of enteropathogens in the phyllosphere: a review. J Appl Microbiol.

5. **Hennessy, T. W., C. W. Hedberg, L. Slutsker, K. E. White, J. M. Besser-Wiek, M. E. Moen, J. Feldman, W. W. Coleman, L. M. Edmonson, K. L. MacDonald, M. T. Osterholm, and T. I. Team.** 1996. A national outbreak of *Salmonella enteritidis* infections from ice cream. N Engl J Med 334:1281-6.

6. **Hettiarachchy, N. S., and E. Satchithanandam.** 2003. Organic acids incorporated edible antimicrobial films. US Patent 10/657,692

7. **Islam, M., J. Morgan, M. P. Doyle, S. C. Phatak, P. Millner, and X. Jiang.** 2004. Fate of *Salmonella enterica* serovar Typhimurium on carrots and radishes grown in fields treated with contaminated manure composts or irrigation water. Appl Environ Microbiol 70:2497-502.

8. **Islam, M., J. Morgan, M. P. Doyle, S. C. Phatak, P. Millner, and X. Jiang.** 2004. Persistence of *Salmonella enterica* serovar Typhimurium on lettuce and parsley and in soils on which they were grown in fields treated with contaminated manure composts or irrigation water. Foodborne Pathog Dis 1:27-35.

9. **Klerks, M. M., M. van Gent-Pelzer, E. Franz, C. Zijlstra, and A. H. van Bruggen.** 2007. Physiological and molecular responses of *Lactuca sativa* to colonization by *Salmonella enterica* serovar Dublin. Appl Environ Microbiol 73:4905-14.

10. **Mukherjee, A., D. Speh, and F. Diez-Gonzalez.** 2007. Association of farm management practices with risk of *Escherichia coli* contamination in pre-harvest produce grown in Minnesota and Wisconsin. Int J Food Microbiol.

11. **Mukherjee, A., D. Speh, E. Dyck, and F. Diez-Gonzalez.** 2004. Preharvest evaluation of coliforms, *Escherichia coli*, *Salmonella*, and *Escherichia coli* O157:H7 in organic and conventional produce grown by Minnesota farmers. J Food Prot 67:894-900.

12. **Sibley, D. A., N. Osna, C. Kusynski, L. Wilkie, and T. R. Jerrells.** 2001. Alcohol consumption is associated with alterations in macrophage responses to interferon-gamma and infection by *Salmonella typhimurium*. FEMS Immunol Med Microbiol 32:73-83.

13. **Tsolis, R. M., R. A. Kingsley, S. M. Townsend, T. A. Ficht, L. G. Adams, and A. J. Baumler.** 1999. Of mice, calves, and men. Comparison of the mouse typhoid model with other *Salmonella* infections. Adv Exp Med Biol 473:261-74.

14. **Wells, J. M., and J. E. Butterfield.** 1997. *Salmonella* contamination associated with bacterial soft rot of fresh fruits and vegetables in the arketplace. Plant Disease 81:867-872.

15. **Zhuang, R. Y., L. R. Beuchat, and F. J. Angulo.** 1995. Fate of *Salmonella* montevideo on and in raw tomatoes as affected by temperature and treatment with chlorine. Appl Environ Microbiol 61:2127-31.